

CORONAL STRUCTURES IN COOL STARS

NASA Grant NAG5-11093

Annual Report

For the period 15 July 2004 through 14 July 2005

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July 2005

Prepared for

National Aeronautics and Space Administration

Washington, D.C. 20546

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<p>The Smithsonian Astrophysical Observatory is a member of the Harvard-Smithsonian Center for Astrophysics</p>

The NASA Technical Officer for this Grant is Ronald Oliverson, Code 681.0 NASA/GSFC.

Program Title: Coronal Structures in Cool Stars
Annual Report: 07/15/2004-07/14/2005
PI: A. K. Dupree, Smithsonian Astrophysical Observatory
NASA: NAG5-11093
SAO: 16613385

1 Scientific Activity

We have extended our study of the structure of coronas in cool stars to very young stars still accreting from their surrounding disks. In addition we are pursuing the connection between coronal X-rays and a powerful diagnostic line in the infrared, the He I 10830Å transition of helium. Highlights of these are summarized below including publications during this reporting period and presentations.

Spectroscopy of the infrared He I ($\lambda 10830$) line with KECK/NIRSPEC and IRTF/CSHELL and of the ultraviolet C III ($\lambda 977$) and O VI ($\lambda 1032$) emission with FUSE reveals that the classical T Tauri star TW Hydrae exhibits P Cygni profiles, line asymmetries, and absorption indicative of a continuous, fast (~ 400 km/s), hot ($\sim 300,000$ K) accelerating outflow with a mass loss rate $\sim 10^{-11}$ – $10^{-12} M_{\odot} \text{ yr}^{-1}$ or larger. Spectra of T Tauri N appear consistent with such a wind. The source of the emission and outflow seems restricted to the stars themselves. Although the mass accretion rate is an order of magnitude less for TW Hya than for T Tau, the outflow reaches higher velocities at chromospheric temperatures in TW Hya. Winds from young stellar objects may be substantially hotter and faster than previously thought.

The ultraviolet emission lines, when corrected for absorption are broad. Emission associated with the accretion flow and shock is likely to show turbulent broadening. We note that the UV line widths are significantly larger than the X-ray line widths. If the X-rays from TW Hya are generated at the accretion shock, the UV lines may not be directly associated with the shock. On the other hand, studies of X-ray emission in young star clusters, suggest that the strength of the X-ray emission is correlated with stellar rotation, thus casting doubt on an accretion origin for the X-rays.

We are beginning to access the infrared spectral region where the He I 10830Å transition occurs. This line is particularly useful as a diagnostic of

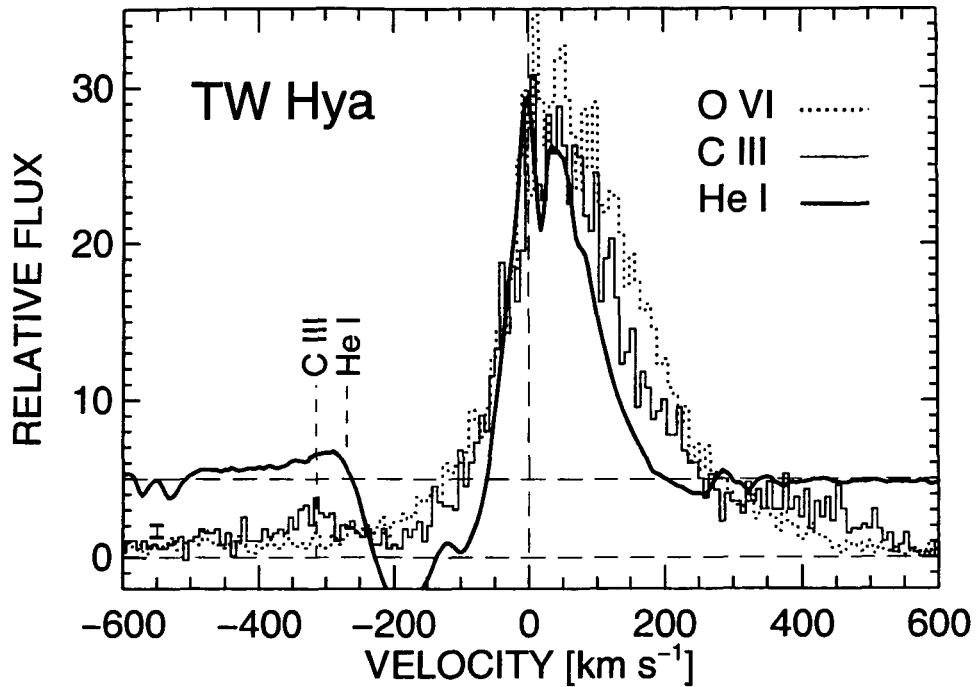


Figure 1: Emission in C III and O VI measured with FUSE; the He I $\lambda 10830$ line was measured with NIRSPEC on KECK II. The P Cygni nature of these profiles demonstrates the presence of an accelerating hot wind arising from this classical T Tauri star itself. From Dupree et al. 2005, ApJ, 625, L131.

coronal radiation since it is formed by recombination following photoionization of neutral helium by coronal X-rays. Because the lower level of the transition is metastable, infrared radiation from the stellar photosphere is absorbed which provides a diagnostic of atmospheric dynamics. This transition is useful both in young stars in the T Tauri phase and in active cool star binaries. We will investigate the influence of coronal x-rays on the strength of this transition.

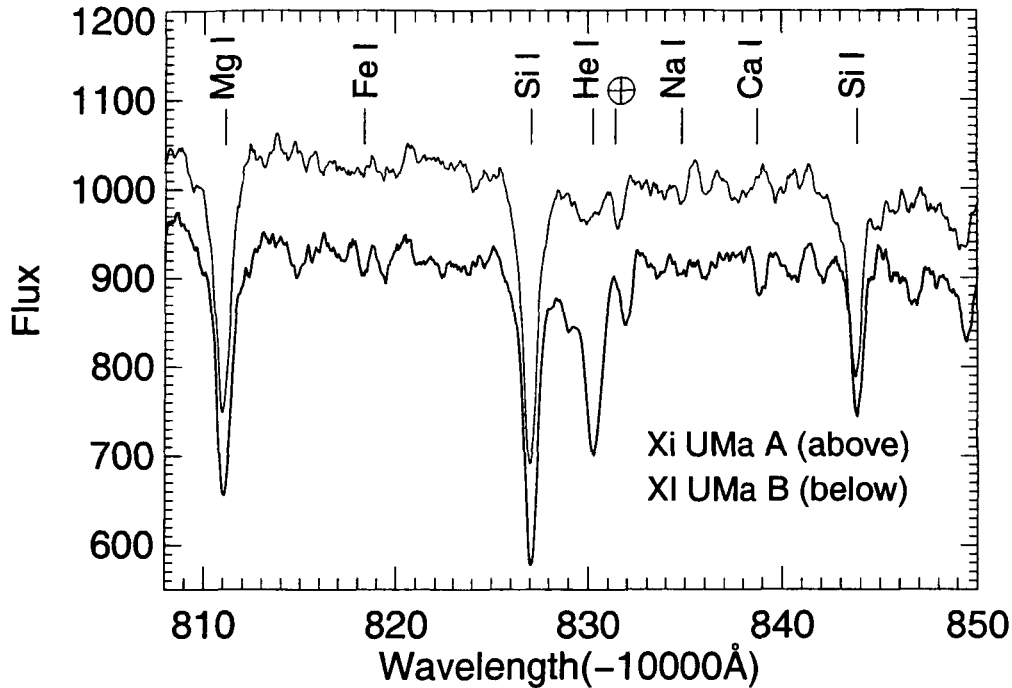


Figure 2: The He I $\lambda 10830$ absorption is extraordinarily strong in the rapidly rotating B component (the G5 V star) of the binary ξ UMa, documenting the enhanced X-ray flux in this star. Contrast this with the weak He I line in the A component. Moreover the He I wing absorption of ξ UMa B extends shortwards towards the photospheric Silicon line indicating fast chromospheric outflow of at least 90 km s^{-1} or greater. Fluxes are scaled for display.

2 Presentations and Publications

A Hot Wind from the Classical T Tauri Stars: TW Hydrae and T Tauri, A. K. Dupree, N. S. Brickhouse, G. H. Smith, & J. Strader, 2005, ApJ, 625, L131.

An Assessment of the Fe XVIII and Fe XIX Line Ratios from the Chandra Grating Observations of Capella, P. Desai, N. S. Brickhouse, J. J. Drake, A. K. Dupree et al., 2005 ApJ, 625, L59

- A Far-Ultraviolet Spectroscopic Survey of Luminous Cool Stars*, A. K. Dupree, A. Lobel, P. R. Young, T. B. Ake, J. L. Linsky, & S. Redfield, 2005, ApJ, 622, 629
- Inferring Coronal Structure from X-Ray Light Curves and Doppler Shifts: A Chandra Study of AB Doradus*, G. A. J. Hussain, N. S. Brickhouse, A. K. Dupree, et al., 2005, ApJ, 621, 999
- He I $\lambda 10830$ Absorption in Metal-Poor Red Giants: Probing Fast Chromospheric Outflows*, G. H. Smith, A. K. Dupree, & J. Strader, 2004, PASP, 116, 819
- Active stars and He I 10830Å: the EUV Connection*, 2005, J. Sanz-Forcada, & A. K. Dupree, 2004, in High Resolution Infrared Spectroscopy in Astronomy, eds. H. U. Käufel, R. Siebenmorgen, & A. Moorwood, ESO Astrophysics Symposia, (Berlin: Springer-Verlag), in press